Announcements

- Homework for tomorrow…

  Ch. 26, Probs. [redacted] & 50

  Ch. 27, Probs. 24 & 26

  CQ7: a. 10 b. 1

  CQ8: 2nC/cm^2

  26.12: a) 0 b) 4,100 N/C

  26.14: a) 0 b) 92,000 N/C

- Office hours…

  MW 10-11 am

  TR 9-10 am

  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm

  F 8-11 am, 2-5 pm

  Su 1-5 pm

Chapter 27

Gauss' Law

(*Conductors in Electrostatic Equilibrium*)

Last time…

- *E-field* of a *infinite plane* of charge..

$$\boxed{E_{plane} = \frac{\eta}{2\epsilon_0}}$$

- E-field of a *sphere* (of radius *R*) of charge..

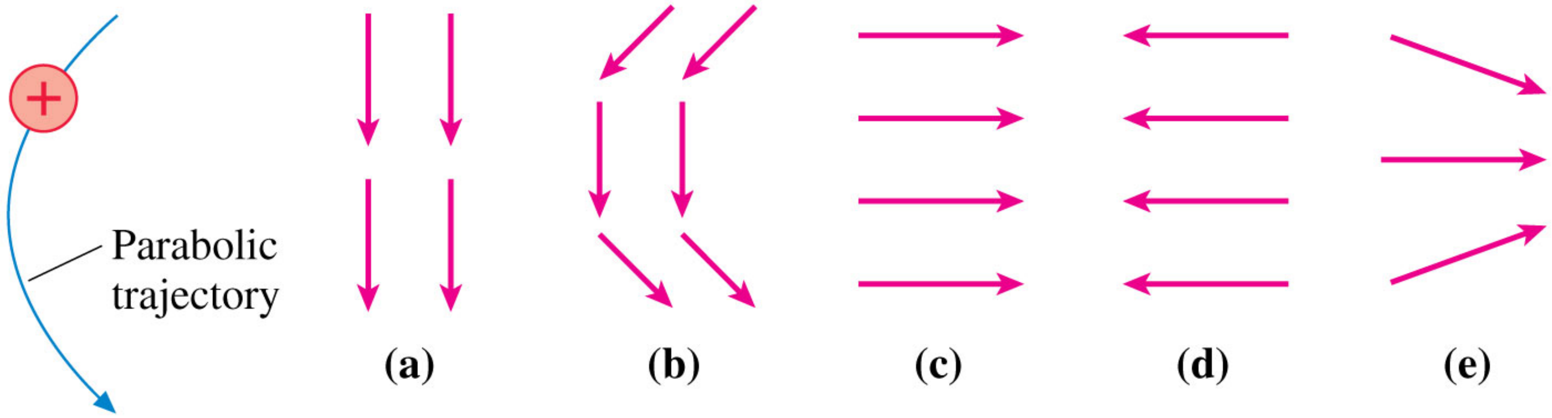
$$\boxed{E_{sphere} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2} \quad \text{for } r \geq R}$$

- *E-field* of a *parallel-plate capacitor*..

$$\boxed{\vec{E}_{cap} = \frac{\eta}{\epsilon_0}}$$

Quiz Question 1

Which E-field is responsible for the proton's trajectory?



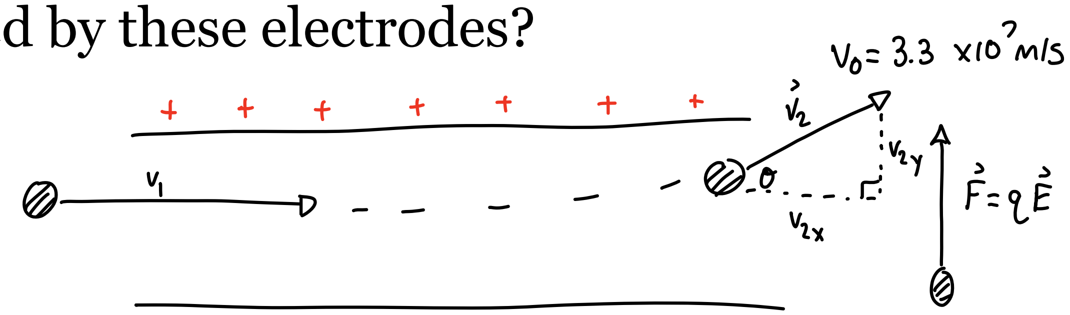
1. (*a*)
2. (*b*)
3. (*c*)
4. (*d*)
5. (*e*)

i.e. 26.9:
Deflecting an e^- beam

An e^- gun creates a beam of e^-'s moving horizontally with a speed of 3.3×10^7 m/s. The e^-'s enter a 2.0 cm long gap between two parallel electrodes where the electric field is

$E = -(5.0 \times 10^4$ N/C) jhat.

In which direction, and by what angle, is the electron beam deflected by these electrodes?



$\Sigma \vec{F}_y = m\vec{a}_y$

$qE = ma$

$$\vec{E} = \frac{\eta}{\epsilon_0} = \frac{Q/A}{\epsilon_0} = \frac{Q}{A\,\epsilon_0}$$

$q = -1.6 \times 10^{-9}$ C

$E = 5.0 \times 10^4$ N/C

$m = 9.11 \times 10^{-31}$ Kg

$a = \frac{qE}{m}$

$\Delta y = V_{1y}\Delta t + \frac{1}{2} a_y \Delta t^2$

$V_{2y} = V_{1y} + a_y \Delta t$

$a_y = 8.8 \times 10^{15}$ m/s^2

$\tan\theta = \frac{V_{2y}}{V_{2x}}$

$V_{2y} = 5.4 \times 10^6$ m/s

$V_{1y} = 3.3 \times 10^7$ m/s

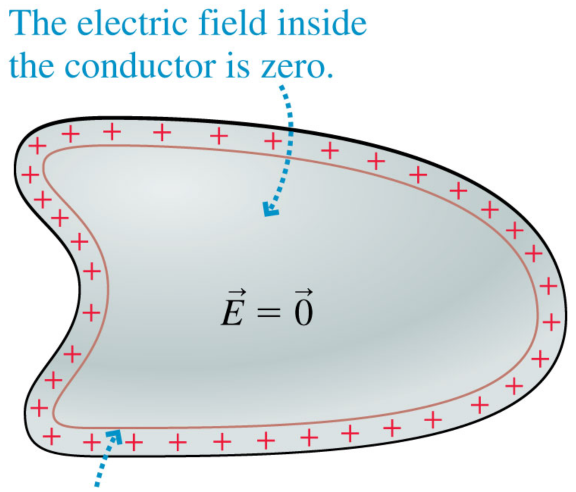
$\theta = \tan^{-1}\left(\frac{5.4 \times 10^6 \text{ m/s}}{3.3 \times 10^7 \text{ m/s}}\right)$

$\theta = 9.3$

27.6: Conductors in Electrostatic Equilibrium

Consider a charged conductor in *electrostatic equilibrium*…

- all charges are *stationary*.



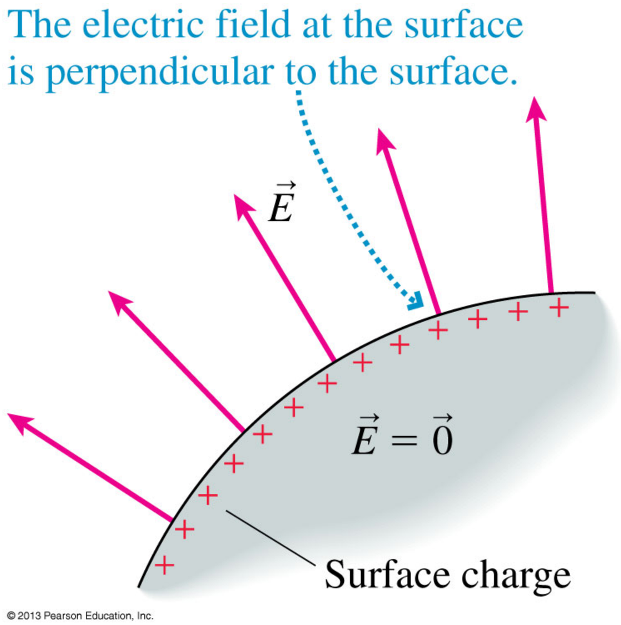
- *E*-field is ZERO at all points w/in the conductor.
- Any excess q resides on the *exterior surface*.

Excess charge resides on the surface

Conductors in Electrostatic Equilibrium

Consider a charged conductor in *electrostatic equilibrium*…

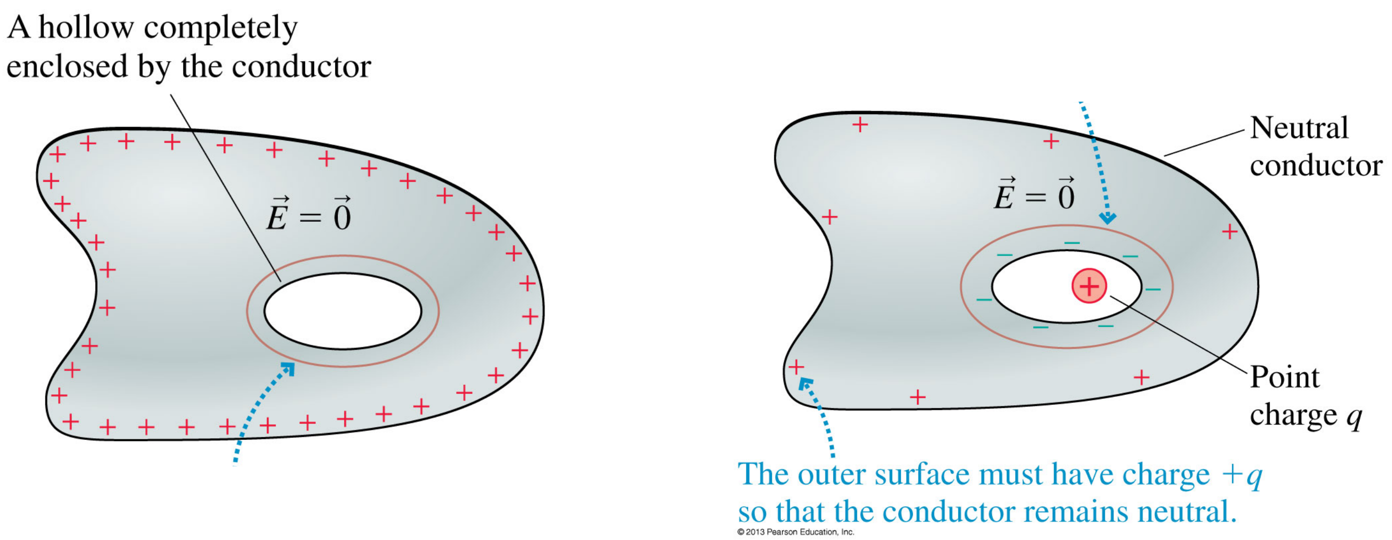
$$\boxed{\vec{E}_{surface} = \frac{\eta}{\epsilon_0}\ ,\ \perp \text{ to surface}}$$



- *E*-field at the surface of a charged conductor..
  - is *perpendicular* to the surface.
  - is of *magnitude* η/ε_o, where η is the surface charge density *at that pt*.

Conductors in Electrostatic Equilibrium

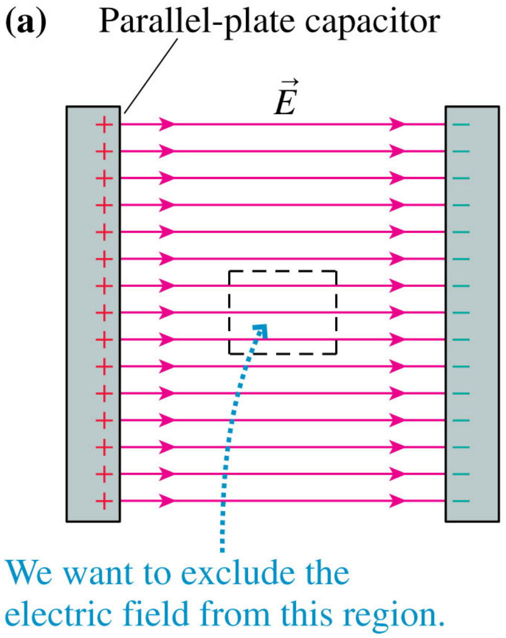
Consider a charged conductor in *electrostatic equilibrium*…



- *E*-field is ZERO inside any hole w/in a conductor, *unless* there is a q in the hole.

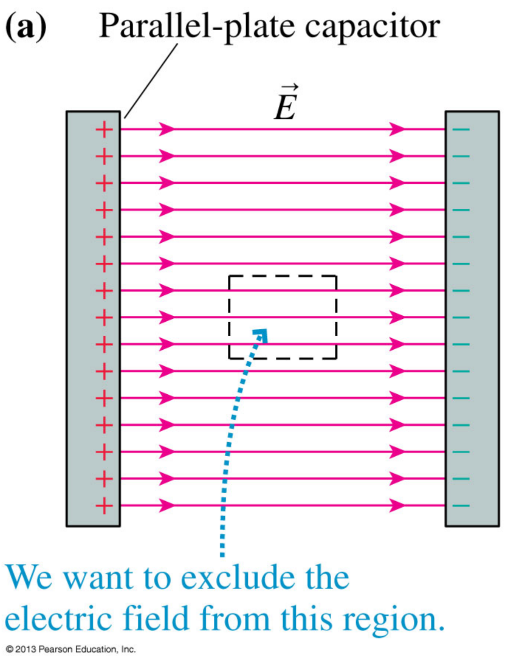
Conductors in Electrostatic Equilibrium

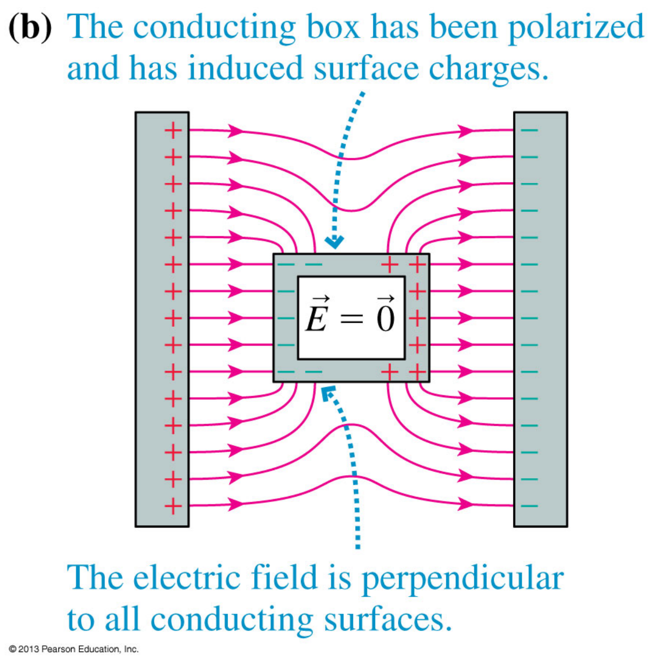
Q: How can we exclude an *E*-field from some region?



Conductors in Electrostatic Equilibrium

Q: How can we exclude an E-field from some region?



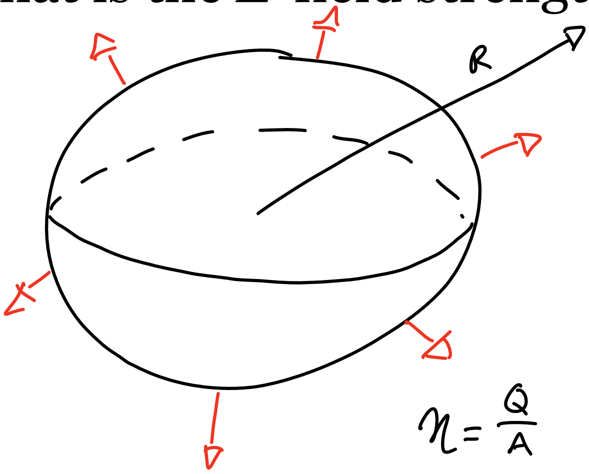


A: Insert a *neutral conducting box* (a.k.a. *Faraday cage*)

i.e. 27.7: The *E*-field at the surface of a charged metal sphere.

A 2.0 cm diameter brass sphere has been given a charge of 2.0 nC.

What is the *E*-field strength at the surface?



$R = 1.0 \times 10^{-3}\, m$

$Q = 2.0 \times 10^{-9}\, C$

$$\vec{E}_s = \frac{KQ}{r^2}$$

$$= \frac{9.0\times10^{9}\,\frac{Nm^2}{C^2}(2.0\times10^{-9}\,C)}{(1.0\times10^{-3}\,m)^2}$$

$$=$$

$$\eta = \frac{Q}{A}$$

$$A = 4\pi r^2$$

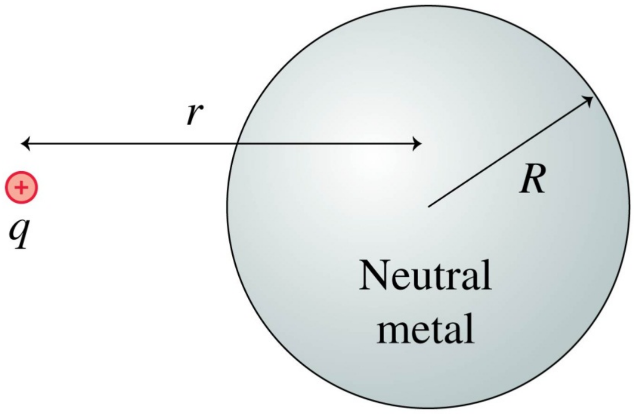
$$E_s = \frac{\eta}{\epsilon_0}$$

$$= \frac{2.0\times10^{-9}\,C}{4\pi(1.0\times10^{-3})^2\, 8.85\times10^{-12}\,\frac{C^2}{Nm^2}}$$

$$= 1.8\times10^{5}\, N/C$$

Quiz Question 2

A point charge q is located a distance r from the center of a neutral metal sphere. The E-field at the center of the sphere is



1. $\dfrac{q}{4\pi\epsilon_0 r^2}$
2. $\dfrac{q}{4\pi\epsilon_0 R^2}$
3. $\dfrac{q}{4\pi\epsilon_0 (R-r)^2}$
4. 0 Always zero insid
5. It depends on the type of metal.